STARS commissioning experiment at Yale

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Motivation

Experimental details Si particle detectors, YRAST ball, geometry of the setup

Data analysis: energy spectra, time spectra, correlation front-back matrices,

E-ΔE matrices, gamma rays gated by particles.

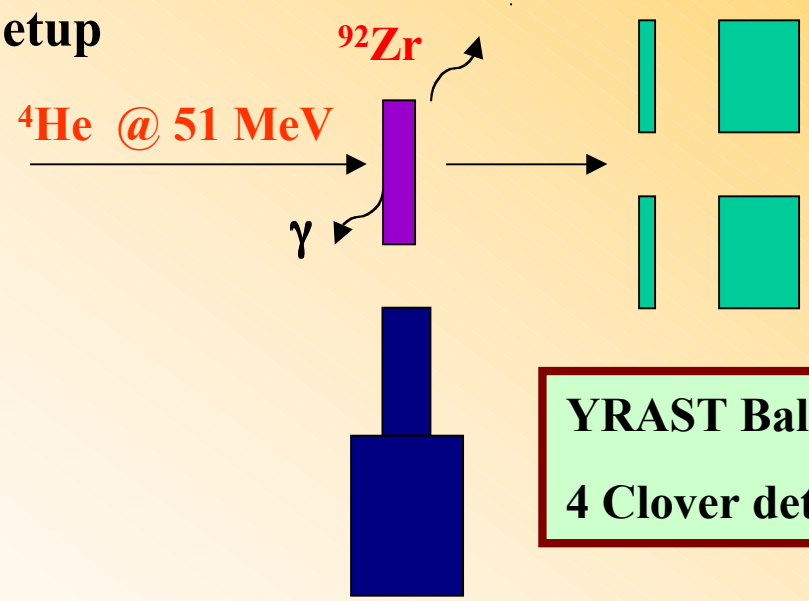
Future steps

Motivation

- **Surrogate reactions on actinide targets to measure cross sections of interest to the stockpile stewardship program**
- **Apparatus**
- **STARS and YRAST Ball at Yale (STARY ?) (SPEEDY, NYPD, MACY...)**
- **Before running with radioactive targets we have to prove (to the university RSO and WNSL operators) the reliability and safety of the system**
  - **Elaborate safety modifications of the vacuum systems**
  - **Several modifications to the YRAST Ball beam line and to the STARS chamber**
  - **Successful commissioning Experiment on Stable Target**
  - **Commission electronics and data acquisition;**

Experimental details

•Setup



STARS

2 annular Si detectors

Thin ... 140 μm

Thick ... 900 μm

8 Sectors (16 physical)

24 rings (48 physical)

YRAST Ball

4 Clover detectors at 90°

Energy Plus Time for each channel (Si or Ge): Total = 96 channels.

•Trigger: STARS (Front Sector OR Ring) AND (Back Sector OR Ring)

•Prompt Trigger: 200 ns

•Master Trigger Rate: 800 –1000 Hz

• ~ 2 days effective beam on target

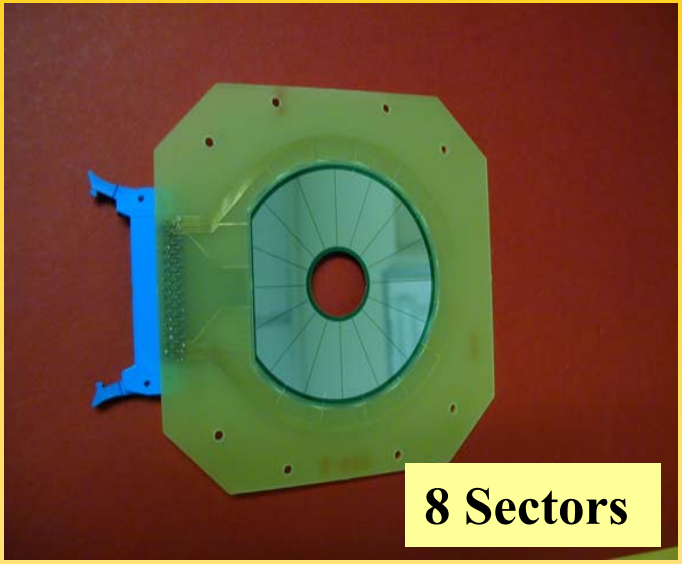
•NOTE: All ENEGY ADC's have a common slow gate 14 μs width.

•Remove randoms by requiring valid TIME (TDC range 1.2 μs).

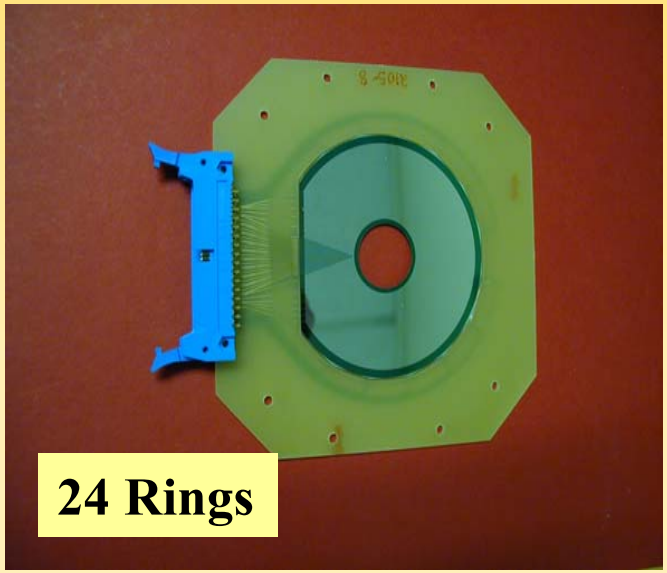
STARS - Si Telescope Array for Reaction Studies

Characteristics:

- **Inner radius 11 mm**
- **24 rings (1mm)**
- **ΔE … 140 μm (thin)**
- **E … 900 μm (thick)**
- **Resolution: 40 keV @ 1 MeV**



- **Angular range:**
  - **Minimum angle front + back : 39.38º**
  - **Maxímum angle front + back : 63.20º**
  - **Solid angle coverage: 16.10% of 4π**

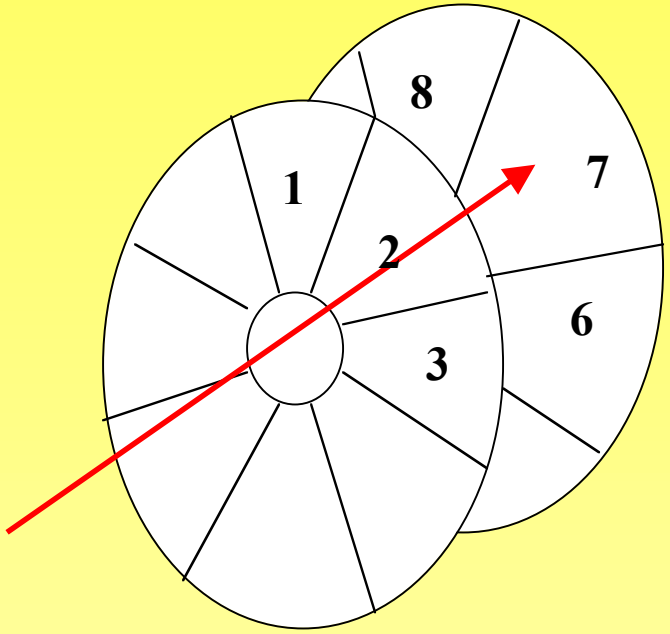


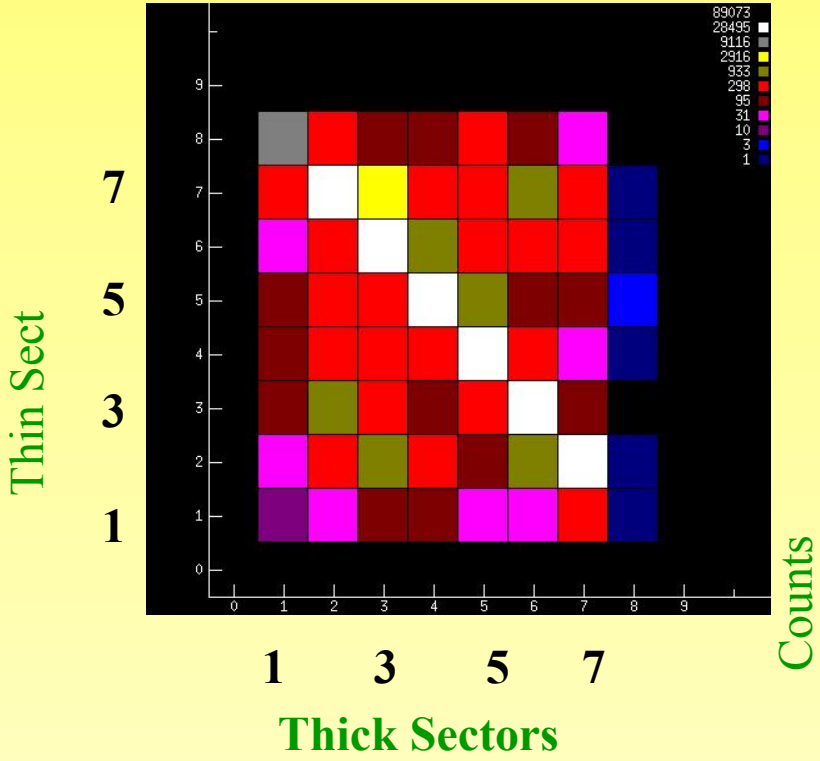
Strategy plan

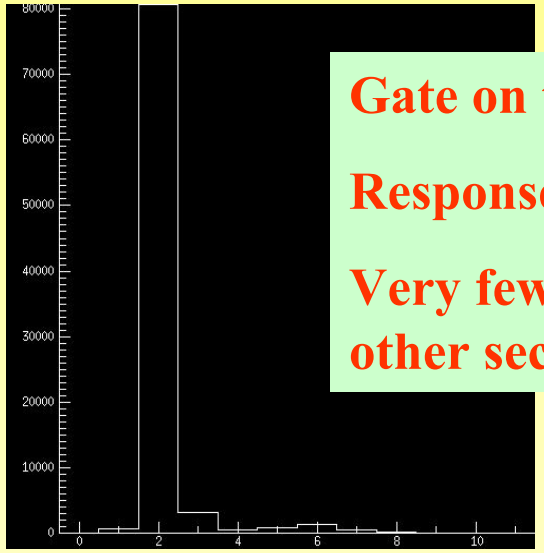
- Energy Calibration (Jennifer Church LLNL)
- Reality Check (e.g., Cabling and data acquisition) (Cristina Plettner Yale)
  1. Sector Mapping (which thick sector one is really behind each thin one)
  2. Ring Mapping ... Ditto
- Understand features present in Si Spectra
- Gate on various distributions and project gamma-ray spectra and check reliability of electronics and data acquisition (measure various efficiencies etc.)
- Interpret the data
- Modify/Improve setup for production runs this spring

Sector - Mapping

- **Conditions in the sort:**
  - a valid energy and time in each sector







Gate on thin sector 7

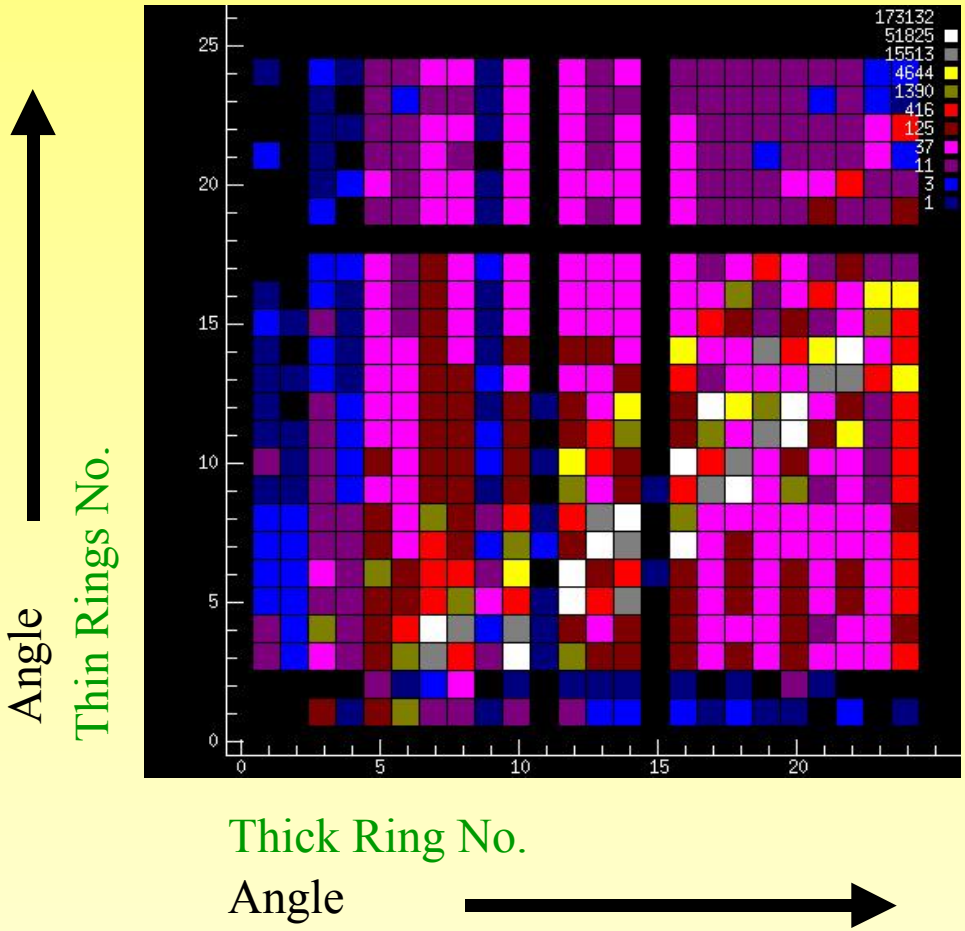
Response: thick sector 2

Very few randoms in other sectors

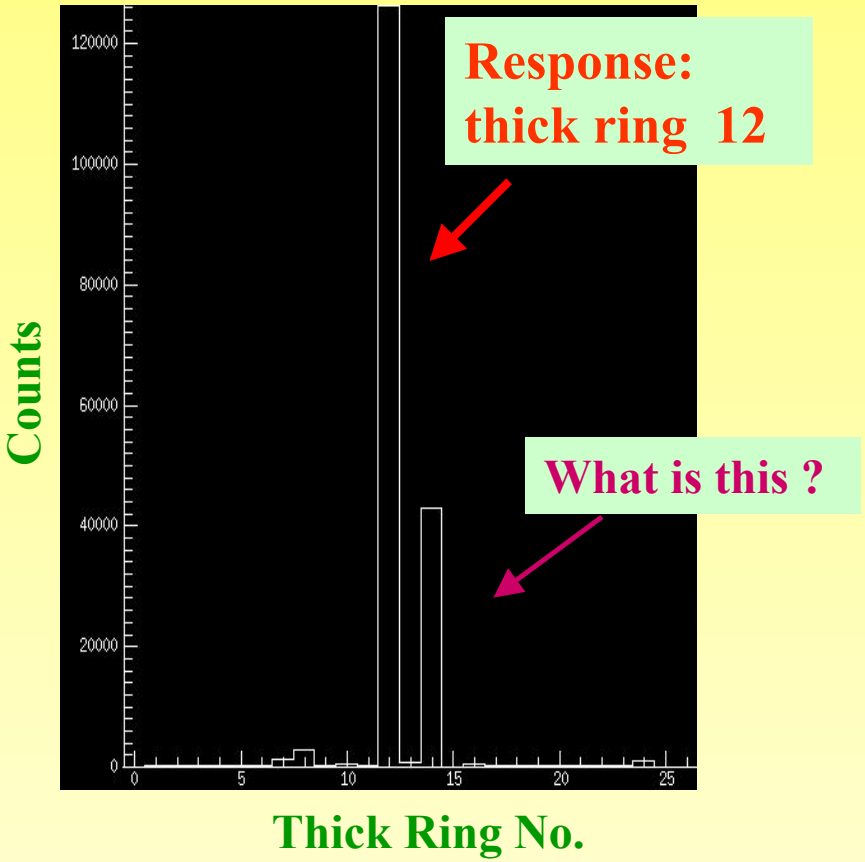
Note: Sectors 1 & 8 are partially masked by the detector support.

Ring-Mapping

- **Conditions in the sort:**
  - **Any Correlated sector-sector pair**
  - **Valid energy and time in any rings**



Gate on thin ring 5



E-ΔE matrices in the sectors

No times on Delta-E

Constant fraction thresholds were too high

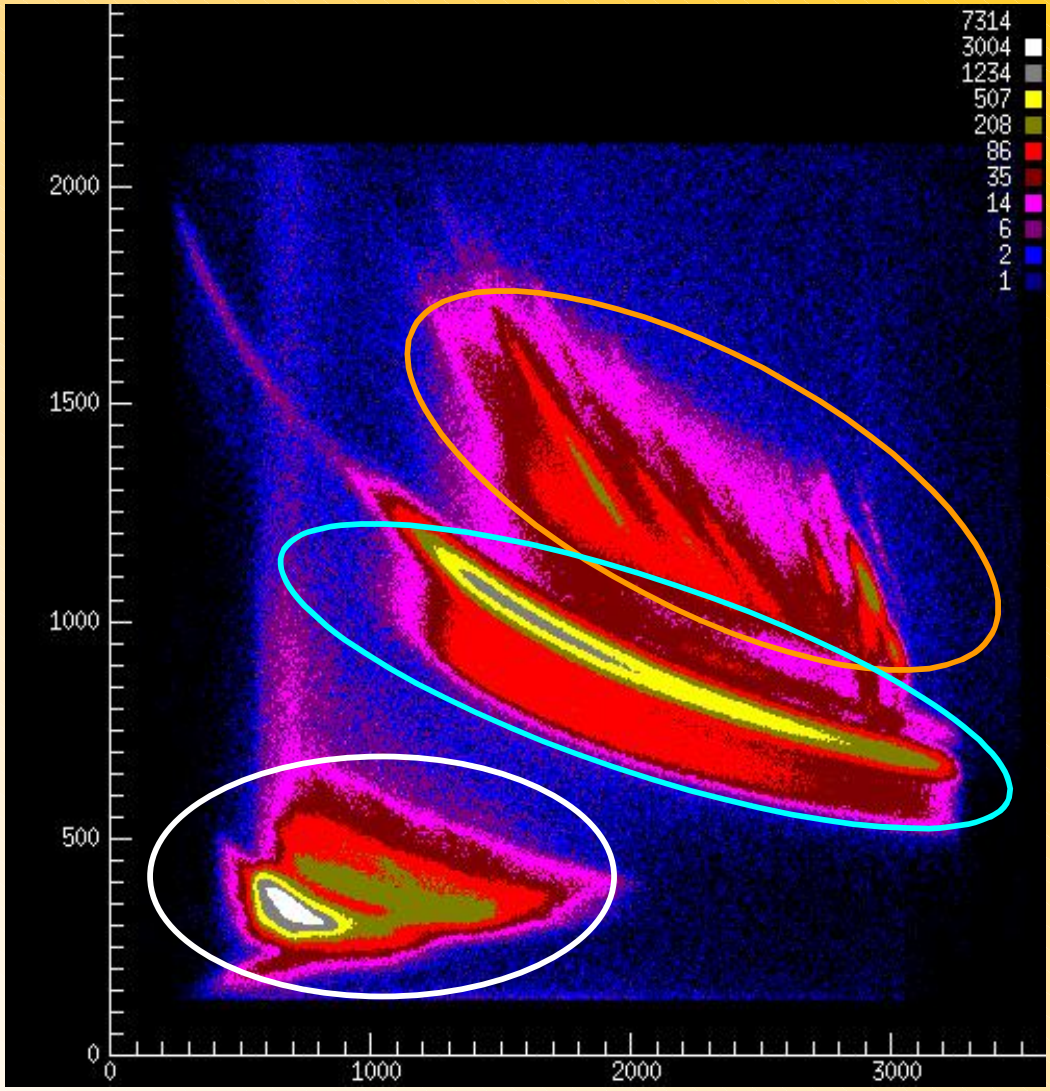
Observe:

Three (or more) distributions

1. **Protons etc ?**
2. **Alphas**
3. **Mystery component**

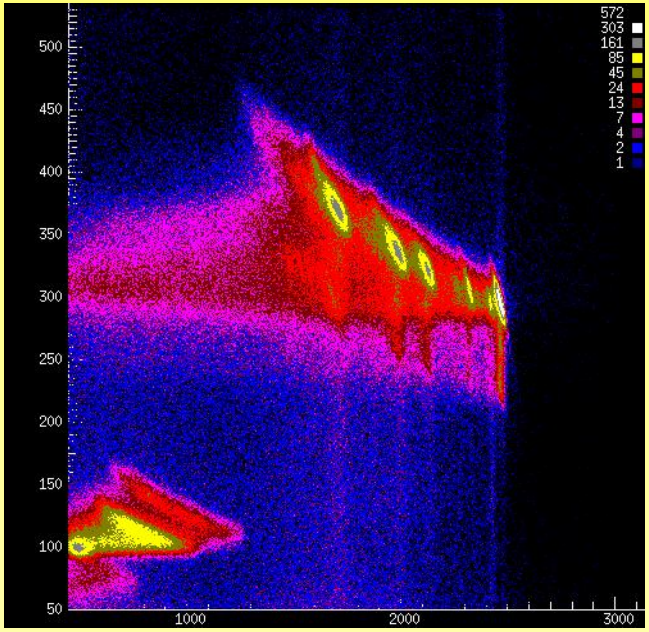
What is the physical origin of the mystery distribution?

(check the geometry!)



E-ΔE matrices in the rings

Thin Ring 3 AND Thick Ring 10



See only ´protons´ and α

^{16}O and ^{12}C target contaminants

Require:

Correlated Sectors

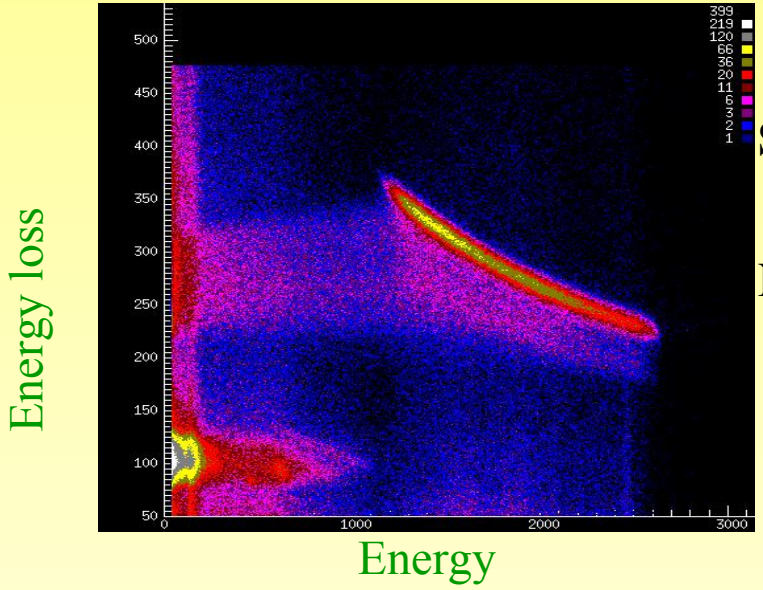
Valid time and energy in thick and thin rings

Valid energy in thick and thin sectors

Valid time in thick sector

Specific Thin-Ring Thick-Ring Combination

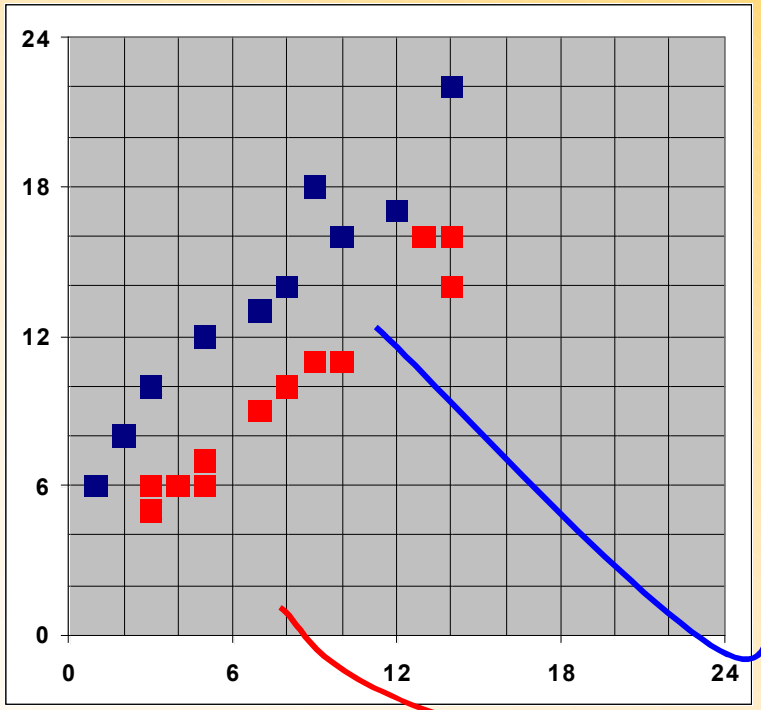
Thin Ring 10 AND Thick Ring 11

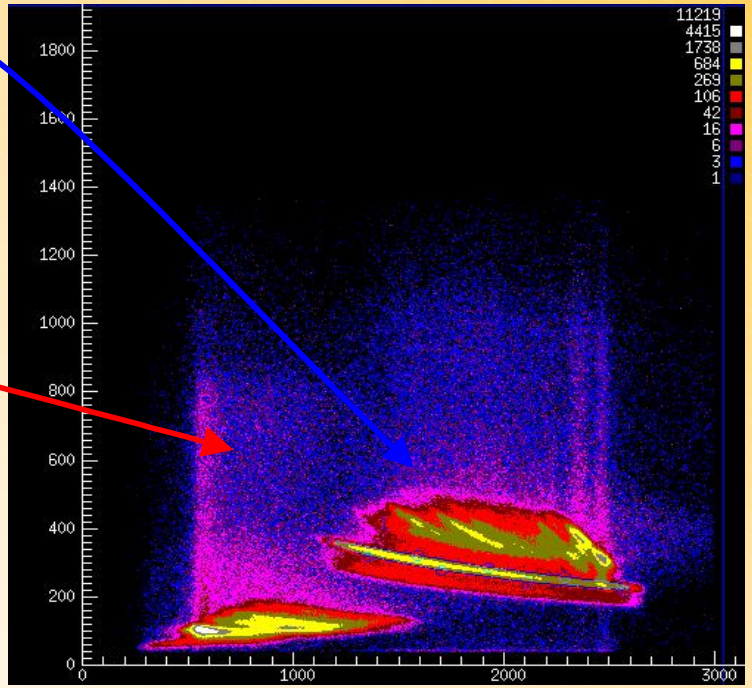


See only mystery distribution

No α

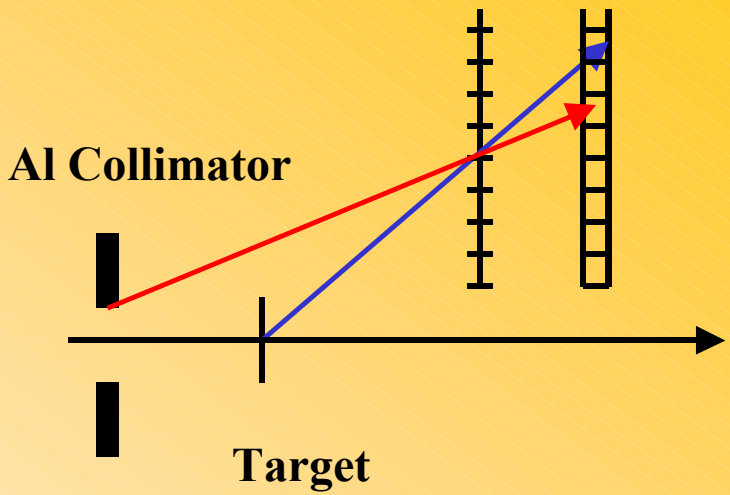
Are there trends ?





Each square represents a specific thin-thick ring pair where the distribution is observed

Possible explanation



Come from different physical locations

Use these data and known detector/target geometry to extrapolate to beam axis and discover the source of these events

Assuming: Geometry is precise!

If z = 0 = target position

then

^{3}He ... from z = 5 +/- 3 mm

Mystery ... from z = -20 +/- 8 mm

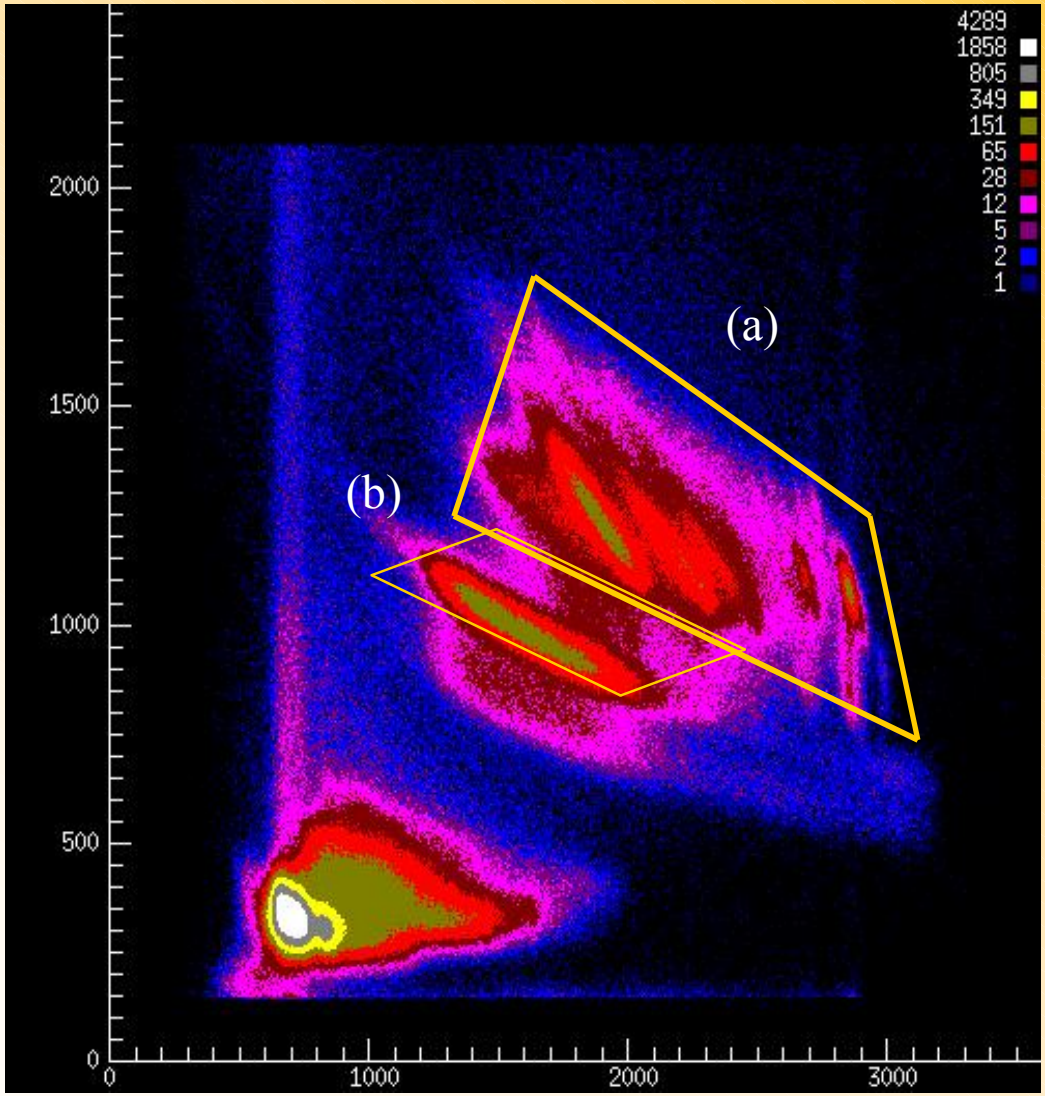
Therefore:

Small (~ 2 mm) error in geometrical setup (know He is correlated with Zr gamma-rays)

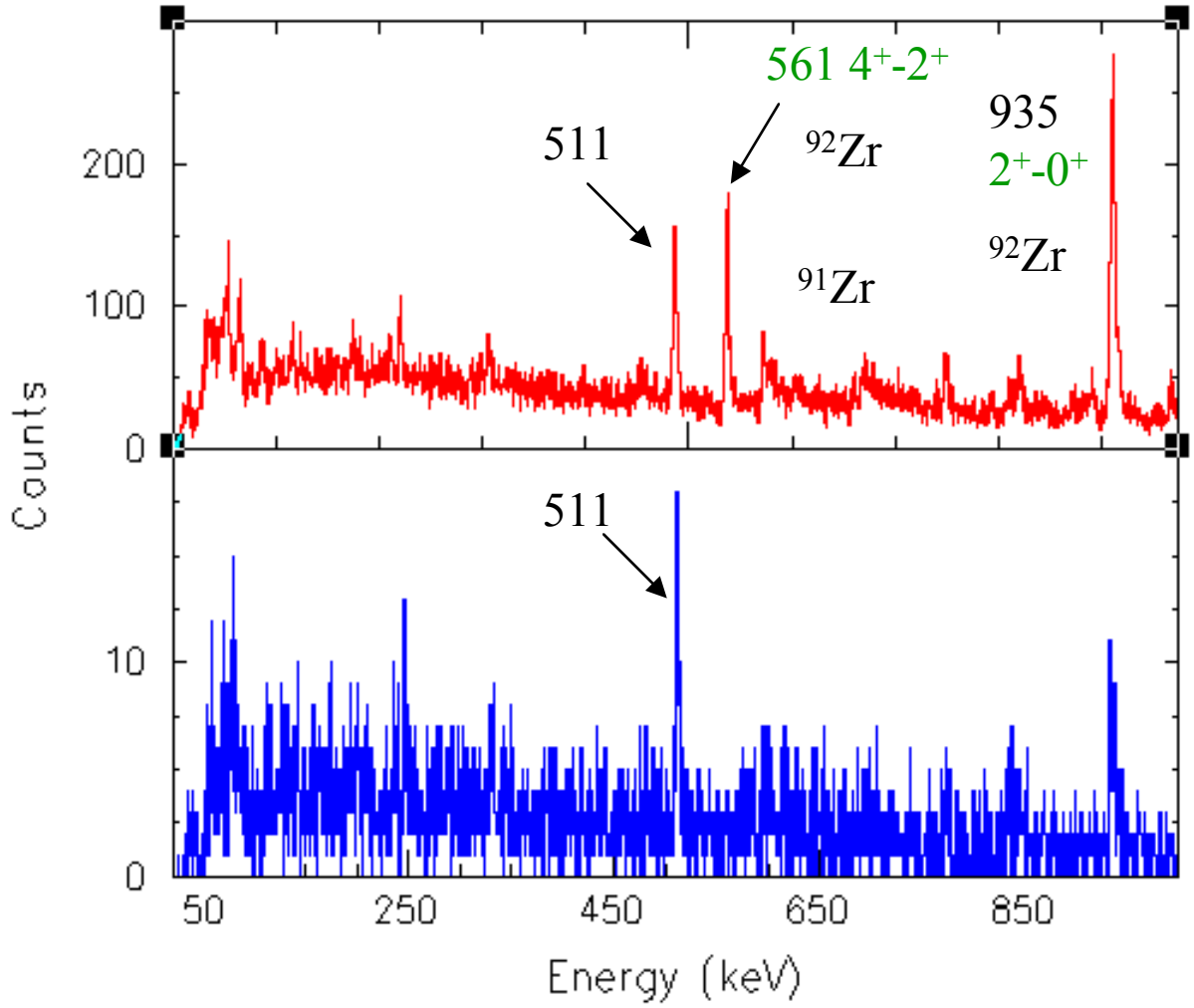
Mystery ... Beam halo from up-stream Al collimator

Fortunately ... Does not interfere with real correlation since different ring-ring combination

Gamma Correlation



Particle gates on the rings

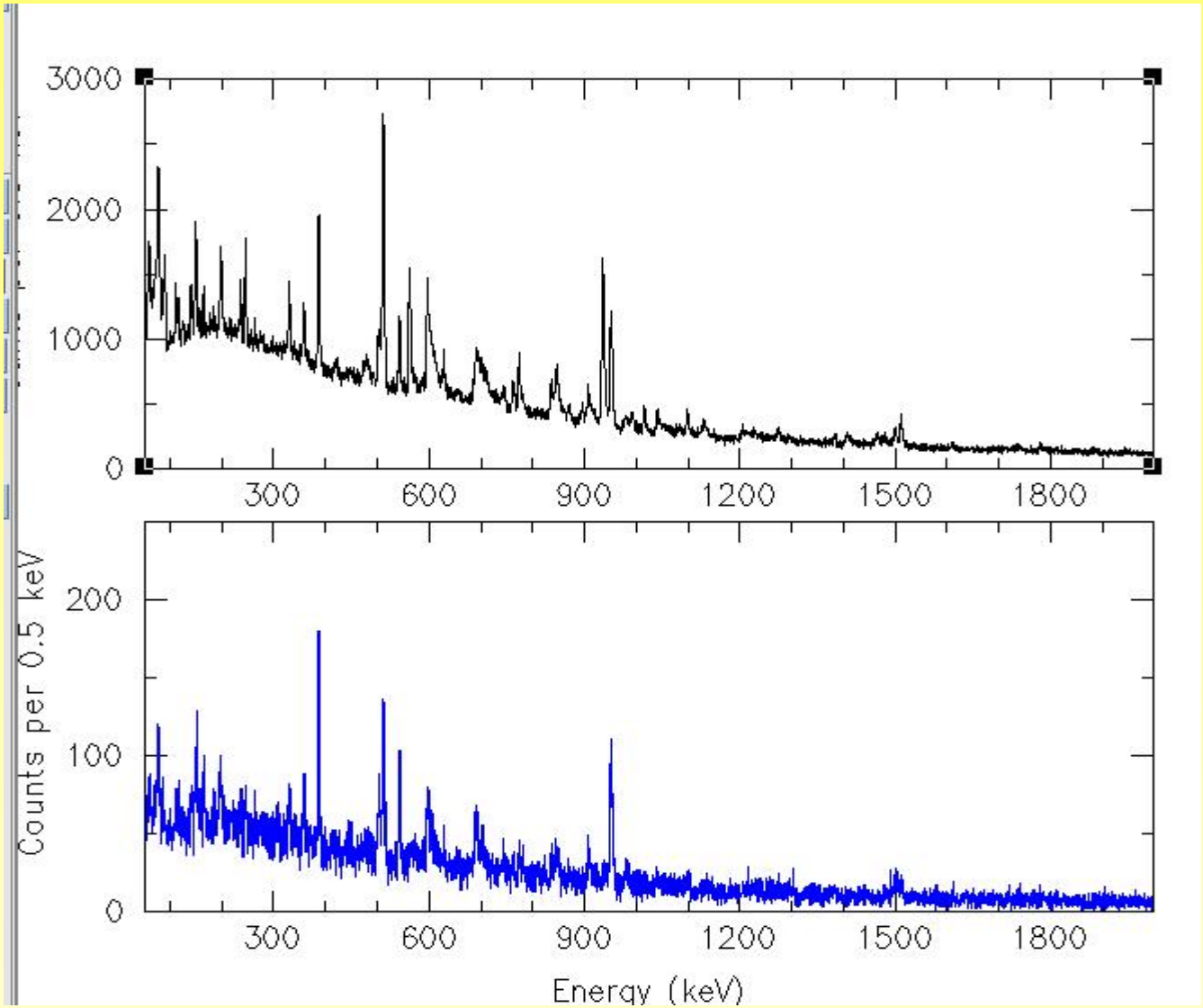


Conclusions

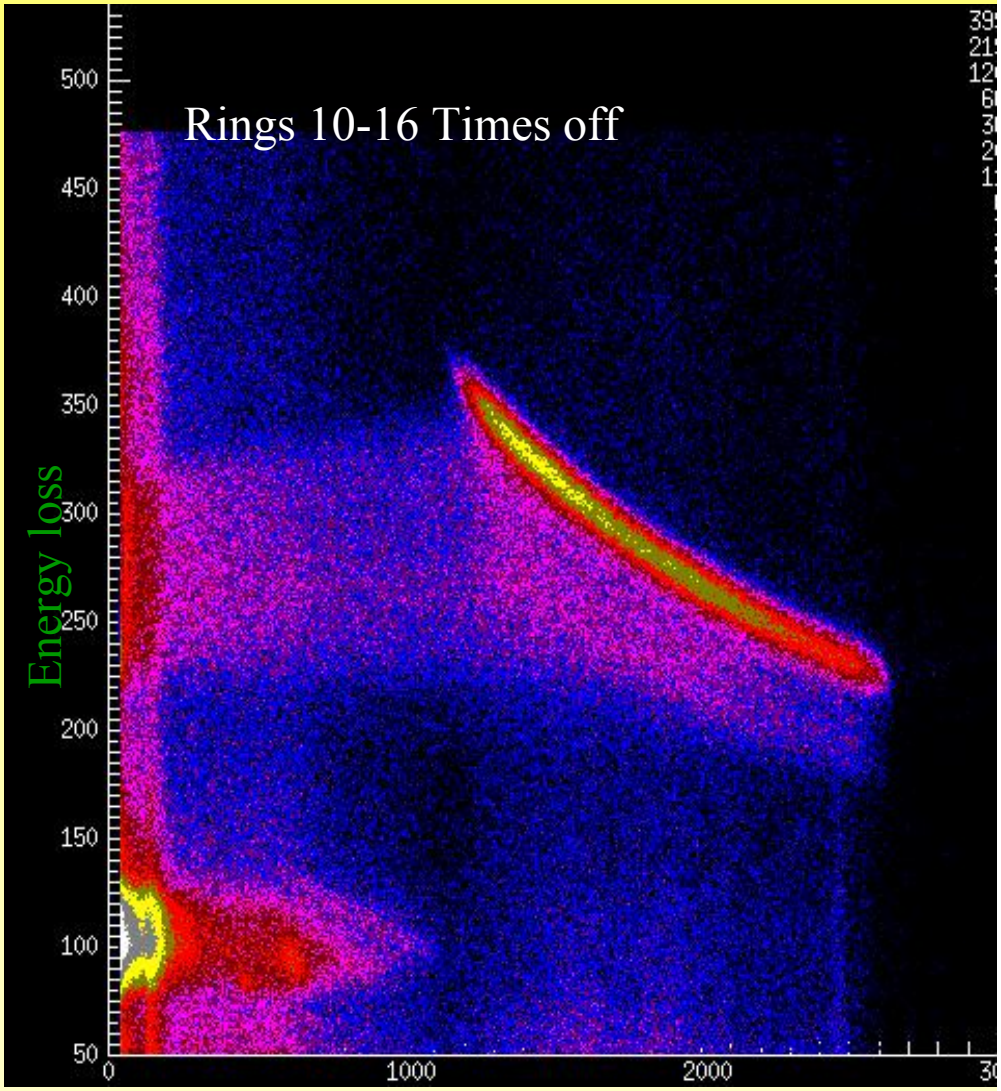
- We have performed (^{4}He, ^{4}He') reaction on a ^{92}Zr target, as surrogate for n + ^{91}Zr
- The correlation thin-thick sectors-sectors and rings-rings, respectively, was found out;
- Energy loss versus residual energy matrices constructed and the ^{4}He distribution identified, as well as gamma rays in coincidence with particles.
- The next step would be to refine the energy calibration, to construct the energy loss versus total energy matrices for different correlated pairs (i.e. angles) and to derive the gamma intensities as a function of the excitation energy.
- We have now the analysis programs and the experimental know-how →

ready to enter the mined field of the radioactive targets since we know where the mines are.

Gamma ray spectra



E-ΔE matrices of the rings



Particle gates on the sectors